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Roadmapping – A Tool for Resolving Science and Technology Issues Related to Processing, Packaging, and Shipping Nuclear Materials and Waste

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ROADMAPPING – A TOOL FOR RESOLVING SCIENCE AND TECHNOLOGY ISSUES RELATED TO PROCESSING, PACKAGING, AND SHIPPING NUCLEAR MATERIALS & WASTE

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Abstract

Roadmapping is an effective methodology to identify and link technology development and deployment efforts to a program's or project's needs and requirements. Roadmapping focuses on needed technical support to the baselines (and to alternatives to the baselines) where the probability of success is low (high uncertainty) and the consequences of failure are relatively high (high programmatic risk, higher cost, longer schedule, or higher ES&H risk). The roadmap identifies where emphasis is needed, i.e., areas where investments are large, the return on investment is high, or the timing is crucial.

The development of a roadmap typically involves problem definition (current state versus the desired state) and major steps (functions) needed to reach the desired state. For Nuclear Materials (NM), the functions could include processing, packaging, storage, shipping, and/or final disposition of the material. Each function is examined to determine what technical development would be needed to make the function perform as desired. This requires a good understanding of the current state of technology and technology development and validation activities to ensure the viability of each step. In NM disposition projects, timing is crucial! Technology must be deployed within the project window to be of value. Roadmaps set the stage to keep the technology development and deployment focused on project milestones and ensure that the technologies are sufficiently mature when needed to mitigate project risk and meet project commitments.

A recent roadmapping activity involved a 'cross-program' effort, which included NM programs, to address an area of significant concern to the Department of Energy (DOE) related to gas generation issues, particularly hydrogen. The roadmap that was developed defined major gas generation issues within the DOE complex and research that has been and is being conducted to address gas generation concerns. The roadmap also provided the basis for sharing "lessons learned" from R&D efforts across DOE programs to increase efficiency and effectiveness in addressing gas generation issues.

The gas generation roadmap identified pathways that have significant risk, indicating where more emphasis should be placed on contingency planning. Roadmapping further identified many opportunities for sharing of information and collaboration. Roadmapping will continue to be useful in keeping focused on the efforts necessary to mitigate the risk in the disposition pathways and to respond to the specific needs of the sites.

Other areas within NM programs, including transportation and disposition of orphan and other nuclear materials, are prime candidates for additional roadmapping to assure achievement of timely and cost effective solutions for the processing, packaging, shipping, and/or final disposition of nuclear materials.

Roadmapping Defined

A roadmap is a portrayal of the research and development (R&D) activities and schedule necessary to manage technical risks and opportunities associated with a complex problem. Roadmapping helps identify technical capabilities required for both project- and program-level efforts and provides the basis for project plans that ensure the necessary knowledge and technologies will be available when needed.

The Steps of Roadmapping

The typical steps of roadmapping are as follows:
Step 1: Problem Definition – The development of a roadmap typically involves the problem definition (current state versus the desire state) and the major steps (functions) needed. For Nuclear Materials (NM), that could include processing, packaging, storage, shipping, and/or final disposition of the NM.
Step 2: Needs Assessment – Each function is examined to determine what technical development would be needed to make the function perform as desired. This requires a good understanding of the current state of technology and technology development and validation activities to ensure the viability of each step. The timing to have the technology in place is also captured to identify those applications where emphasis should be placed and to prioritize where resources should be allocated.
Step 3: Technical Response – The path to develop the current state into the desired state is mapped out.
Step 4: Roadmap Implementation – The roadmap report is reviewed, released, and implemented. Implementation plans are developed, budgets and schedules are allocated, and work plans are implemented and tracked.

Benefits of Roadmapping

Roadmapping provides several benefits at both the project and the program levels:
- Supports decision-making and problem-solving by having the right information available at the right time
- Develops a consensus among users, providers, and management about what R&D is needed and why
- Coordinates R&D, engineering, and management to achieve technically defensible program decisions and facility plans
- Helps reduce life-cycle costs and technical risks and improve cleanup and stewardship solutions

Roadmapping reveals where to focus further development of the path forward by evaluating uncertainties for levels of complexity, impacts, and/or the potential for large payback.

The following are examples of the results from prior roadmapping efforts:
- Faster – Savannah River Site (SRS) resolved salt disposition viability issues in 10 months versus an estimated 36 months
- Cheaper - INEEL reduced calcine R&D costs from $105 million to $25 million
- Better - Hanford resolved Vadose Zone cesium transport issues supporting credible risk assessment and closure planning

Gas Generation Roadmap Example

Gas generation issues, particularly hydrogen, have been an area of concern for the transport and storage of radioactive materials and waste in the Department of Energy (DOE) Complex. Potentially combustible gases can be generated through a variety of reactions, including chemical reactions and radiolytic decomposition of hydrogen-containing materials. Since transportation regulations prohibit shipment of explosives and radioactive materials together, it was concluded that hydrogen generation was a problem that involved a number of programs and warranted the execution of a high-level roadmapping effort.

Research and development (R&D) activities have been and are being conducted by the nuclear materials, transuranic (TRU) waste, and spent nuclear fuels (SNF) programs within DOE's Environmental Management (EM) organization to address gas generation concerns. In an effort to understand the programmatic risk associated with the issue of gas generation, a "program level" roadmap was prepared that linked technology development to program functional needs and identified the probability of success. In other words, since gas generation was an issue to more than one function in more than one program, it was deemed worthwhile to develop a program level roadmap to look for potential synergies across these programs and functions. This roadmapping effort focused on needed technical support to the baselines (and to alternatives to the baselines) where the probability of success was low (high uncertainty) and the consequences of failure were relatively high (high programmatic risk). This roadmapping also provided the basis for sharing "lessons learned" from research and development (R&D) efforts across DOE programs to increase efficiency and effectiveness in addressing gas generation issues.

Gas Generation Roadmapping Approach And Methodology

Development of the roadmap involved identifying the major steps needed for final disposition of the waste/material (or for storage pending disposition) and the associated R&D and certification activities required to ensure the viability of each step. Four major functions were identified: (1) treatment, (2) packaging, (3) transportation, and (4) disposal/storage. Each of these functions was examined to determine what technical support would be needed to make the function successful. The timing to have the technology in place was also captured to identify those areas where emphasis should be placed or where resources should be reallocated. Figure 1 provides a graphical depiction of the nuclear materials portion of the roadmapping effort.

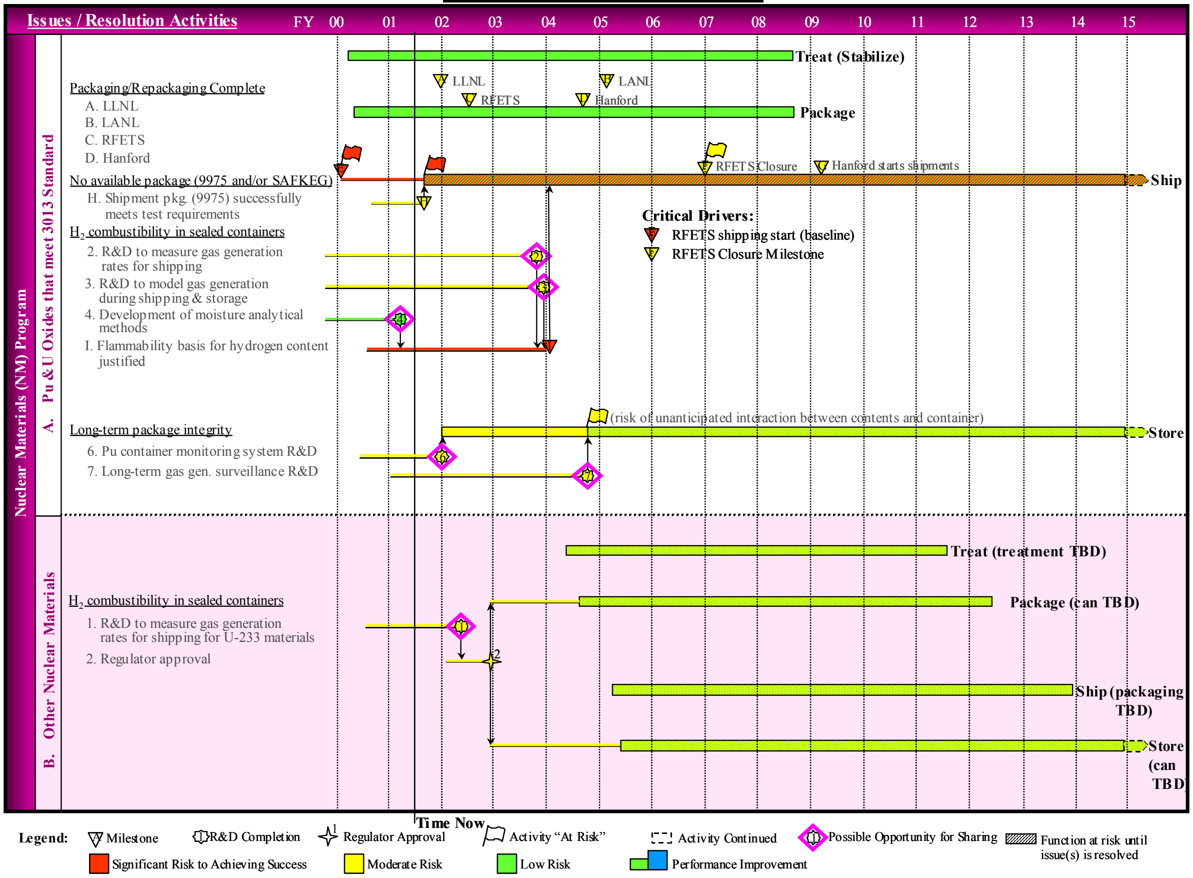
Gas Generation Roadmap Recommendations

There were four areas that were identified as having the most potential for sharing of information:

- Mechanisms for gas generation
- Methods for measuring gas generation rates
- Gas generation modeling methodologies
- Approaches for elimination of gas generation or mitigation of impacts:
  - Use of getters
  - Permeable membranes
  - Drying/stabilization techniques
  - Use of inert atmospheres

Contingency planning – Roadmapping revealed that there are pathways that are questionable single solution pathways. Therefore, the Task Group suggested that bottlenecks be defined and plans made as to how to mitigate them. Should a single pathway prove impassible, alternatives should be available to avoid the consequences of "missed" or "slipped" important milestones. The two key potentially questionable pathways were:

Gas Generation Roadmap Summary



Gas Generation Roadmap Summary

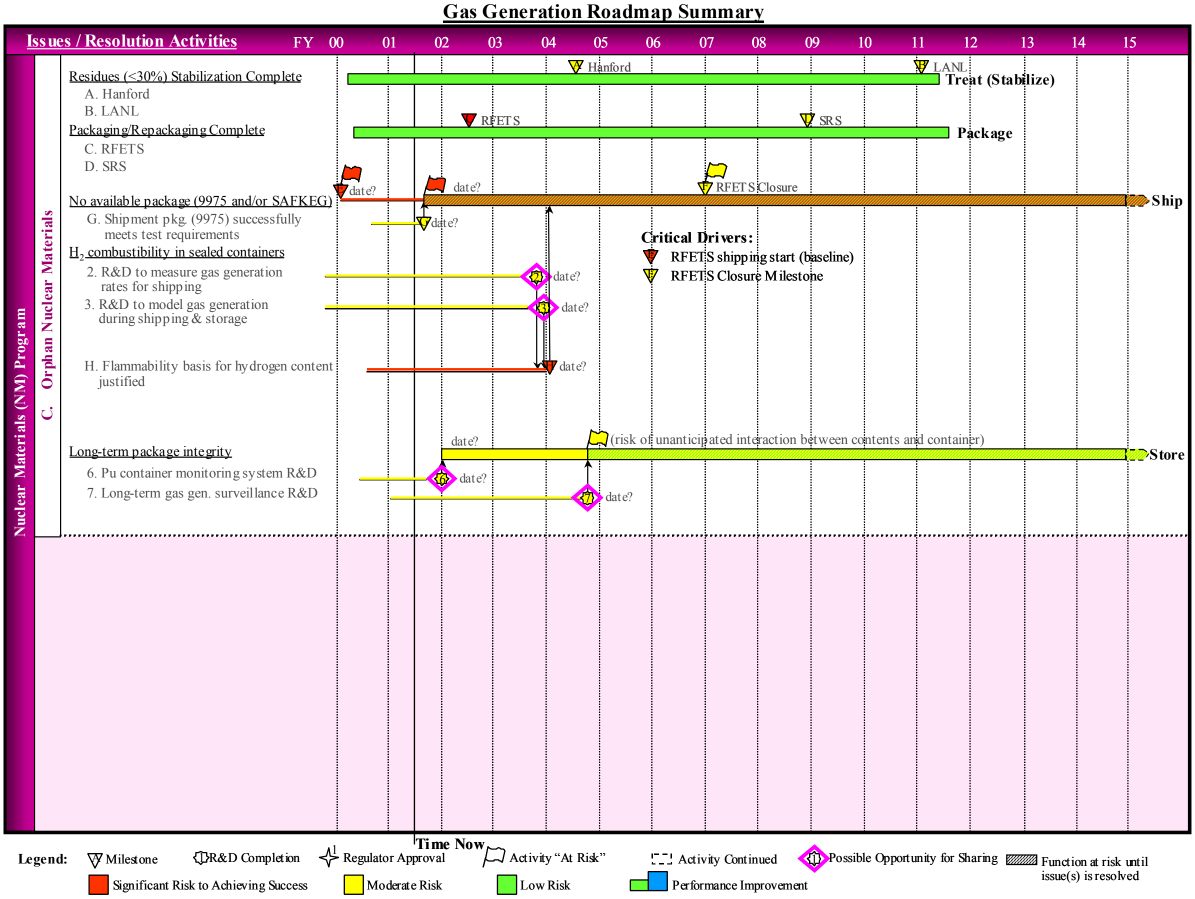


Figure 1 – Nuclear Materials Gas Generation Roadmap Graphical Display

- Rocky Flats Environment Technology Site (RFETS) shipping schedule for impure Plutonium (Pu) oxides and residues which must be expeditiously removed from the site to meet closure milestones
- Acceptance of the use of getters to enhance shipping capabilities and reduce shipping costs

Gas Generation Roadmap Next Steps

The roadmap effort found that gas generation issues can adversely affect DOE milestones in a variety of programs at different sites. It was also recognized that gas generation issues represent a large risk to accomplishing DOE's environmental management mission to clean up DOE sites.

The Task Group that created the roadmap recognized that current research efforts are based on identified needs, but that those efforts could be better coordinated to address the issues. The Task Group recommended that a group of experts from appropriate DOE programs continue to further develop the roadmap to facilitate the prioritization and integration of issues and research efforts.

Deciding Which Nuclear Materials Projects/Programs to Roadmap

Roadmapping is a powerful planning tool. It can be used at different levels of detail, a "graded approach" if you will. At the less detailed end, "mini" roadmaps can be created that tie the needed enablers (e.g., technologies, decisions, etc.) to the functions. Roles and responsibilities are also defined. If it is found during this high level roadmapping that areas of significant risk exist, then those are roadmapped further to a lower level of detail. Otherwise, the mini roadmap may be sufficient to manage the project / program risk.

Roadmapping can be especially useful for programs / projects that are made up of multiple sites, programs, or other entities involved. Increased synergy, better communications, and increased cooperation are the results from roadmapping a program / project with these conditions. The gas generation roadmap is an example of where the mini roadmap concept was utilized in an environment of multiple program involvement.

Roadmapping definitely should be used for high risk, high visibility, high cost, or highly complex projects / programs. Whether to roadmap a particular project / program is subjective. However, if a project / program meets one or more of the following criteria, it is a good candidate for roadmapping:

- The project / program has a high technical risk or is on a site or system closure critical path and has moderate to high technical risk
- The project / program baseline requires the use of unproven technologies
- The project / program is a one-of-a-kind effort with significant consequences for cost or schedule slippage
- Multiple, diverse efforts/entities are working on a common problem
- The project / program is long-term and has high worker exposure, life-cycle dollar, or environmental costs
- The project / program has high political or management visibility

The Right Timing for a Roadmap

Ideally, roadmapping is conducted concurrent with general program and project planning. As alternative approaches to a problem are considered, the science and technology and programmatic activities needed to support each promising approach are identified. A roadmap may also be conducted after the program / project general planning is completed, but the benefit of the effort can be more limited.

As with any trip, the earlier you use a roadmap, the more confidence you will have that you will arrive at your destination with few, if any, problems. The longer the trip or complicated the route, the sooner the map is needed. This analogy holds true for using roadmapping for laying out program / project baselines and any alternative (contingency) plans.

Selecting the Right Participants to do a Roadmap

Participants should be drawn from several areas (functional and physical (locations)) to ensure a diverse multidisciplinary team. This group needs to be able to define the needs and also be able to define what's available and what's required to do the work. For a project-level roadmap, these participants may include project managers, project technical experts, plant engineers, scientists, technology development engineers, and representatives from disciplines such as safety and maintenance. At the program level, participants from other sites, national laboratories, government agencies, universities, and industry should also be considered. Depending on the project or program's public visibility, representatives of regulatory, oversight, and other stakeholder bodies could also be involved.

Roadmapping Costs and Time to Prepare

A narrowly focused, single site, project-level roadmap or a "mini" roadmap developed by experienced personnel will cost $40-60K and take 2-4 months to complete. A high visibility, broadly focused, detailed site- or complex-wide program-level roadmap developed primarily with participants new to roadmapping can cost over $5M and take up to 2 years to complete. One factor affecting cost is whether the roadmap is developed after or combined with general project scoping and planning. Applying a graded approach to the roadmapping can help keep the costs down. Experience has indicated that it is best to do mini-roadmapping first and then evaluate the risky areas to determine whether to further evaluate those areas. This helps keep the cost much lower. Though typically, roadmapping has proven itself to be very cost-effective.

How Nuclear Materials Programs Can Use Roadmapping to Their Advantage

Roadmapping not only solves problems and gaps, but also can be the mechanism for achieving large performance improvements (gains). In fact, this has been one of the very real benefits that has made roadmapping very cost effective (the gains have been significantly greater than the cost for performing the roadmapping).

It may be of interest that industry also uses roadmapping to set performance goals and plan the development paths needed to realize them. For example, the semi-conductor industry has been using roadmaps for over 10 years and is continually updating them yearly to gain great benefits and achievements.

Nuclear materials programs may also find roadmapping to be very beneficial in analyzing their important problems and functions such as the following:

- Development of packages/containers for shipping and/or storage of the nuclear materials
- Determination of optimal transportation packagings and plans for shipments

- Processing of nuclear materials that is currently unaffordable
- Improvements in efficiency and effectiveness of enrichment processing technologies
- Materials processing and recovery

References

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